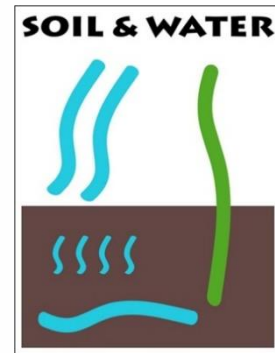


Estonian University of Life Sciences
Institute of Agricultural and Environmental Sciences
Chair of Soil Science

Soil organic matter(s)

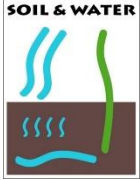
Alar Astover



“International Applied Soil and Plant
Ecology Knowledge” (IntASEK)

Soil organic matter (SOM)

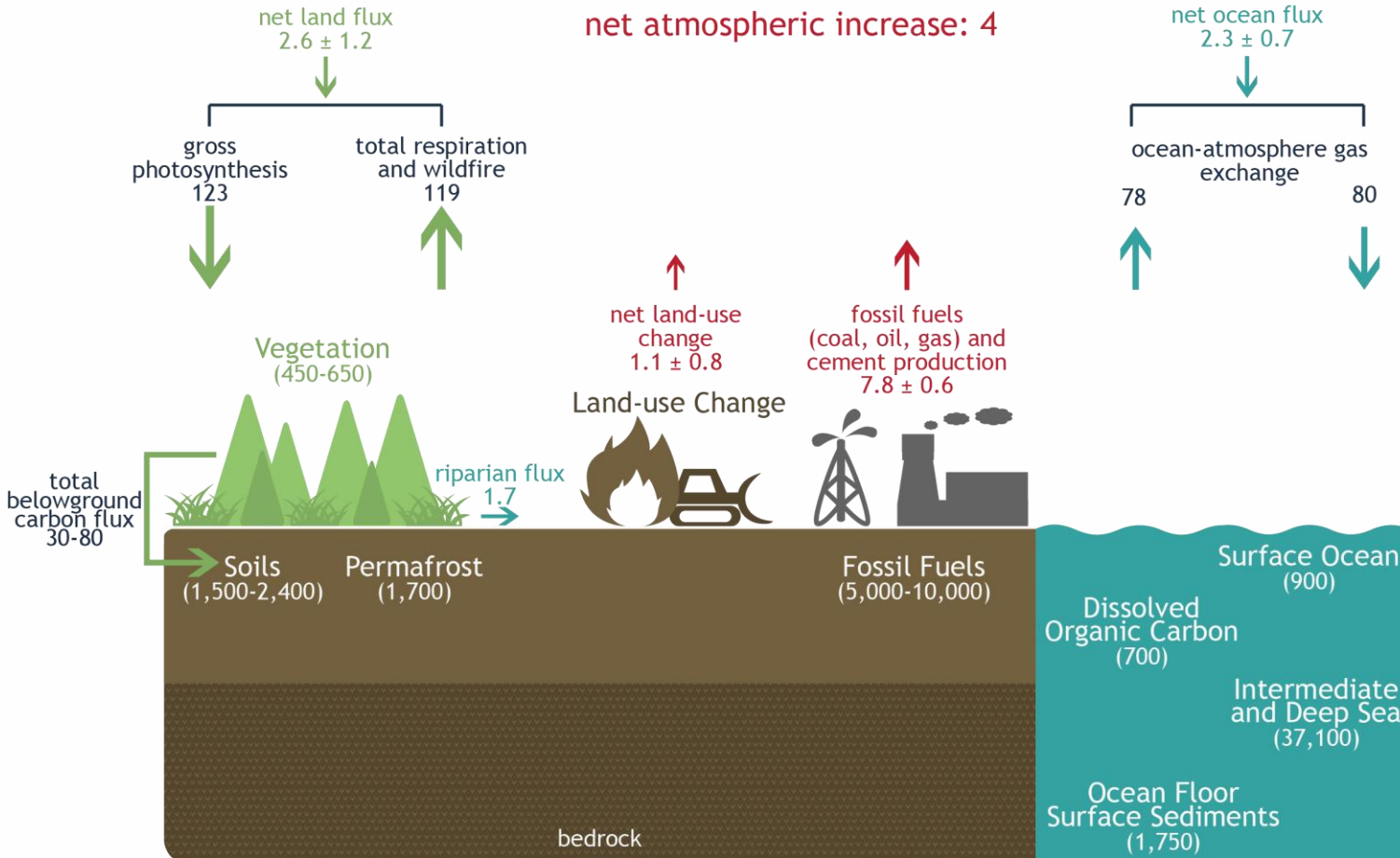
- Origin of soil organic matter?
 - „dead“ organisms (primary and secondary producers) in various stages of decomposition
 - substances released by living organisms (e.g. root exudates) do not „survive“ for long
- Balance between „fresh“ input and decomposition
- Key element is carbon (C)



Global carbon cycle

Atmosphere
(829 ± 10)

net atmospheric increase: 4

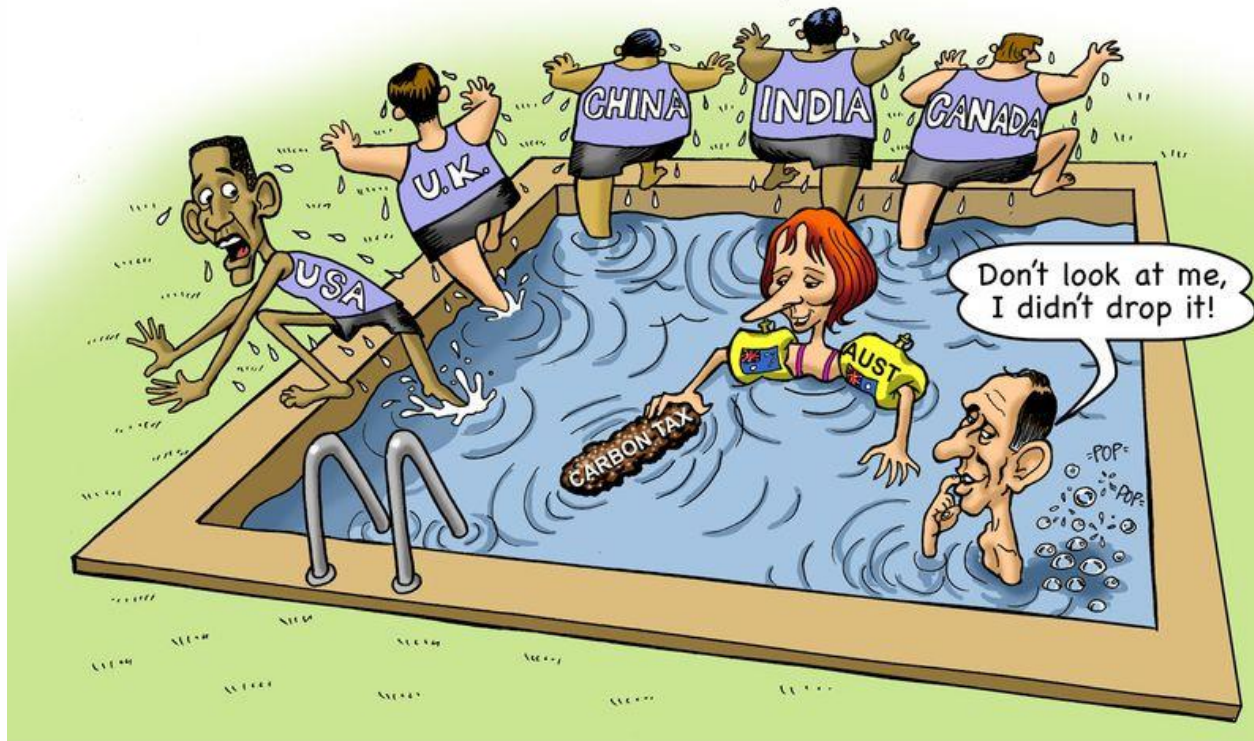


Carbon pool numbers (Gt C) are denoted in (parentheses), and flux numbers (Gt C per year) are associated with arrows

<https://www.fs.usda.gov/ccrc/index.php?q=topics/global-carbon>

- SOM hot topic from anthropogenic view:
 - Indicator of soil quality/fertility
 - Climate change (interaction with atmosphere, source or sink of CO₂)
 - Biodiversity

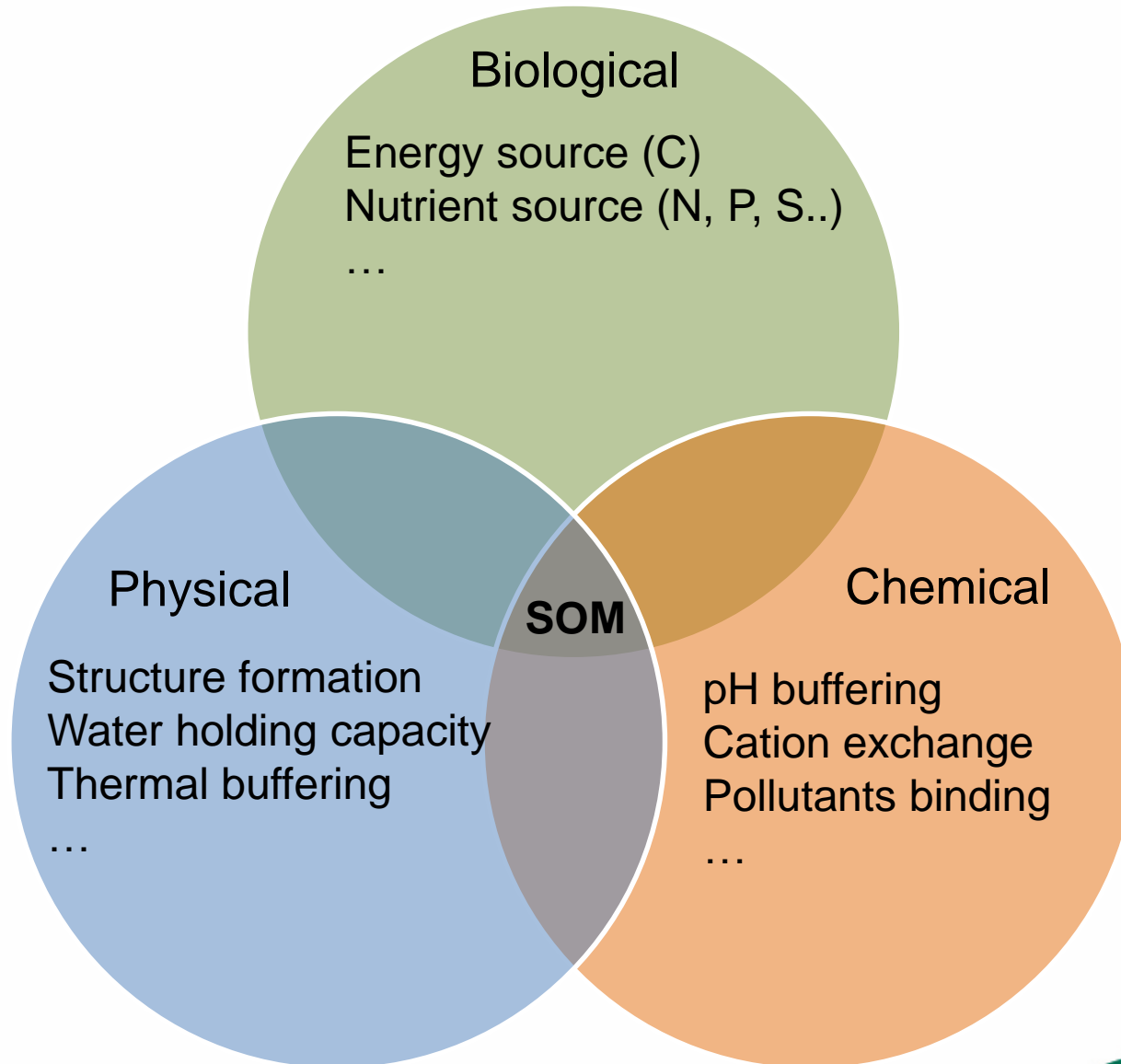
Carbon pool



The Carbon Tax - it's like a turd in a swimming pool

<http://andysrant.typepad.com/blog/2011/11/the-carbon-tax-its-like-a-turd-in-a-swimming-pool.html>

Soil organic matter (SOM) and soil processes/functioning



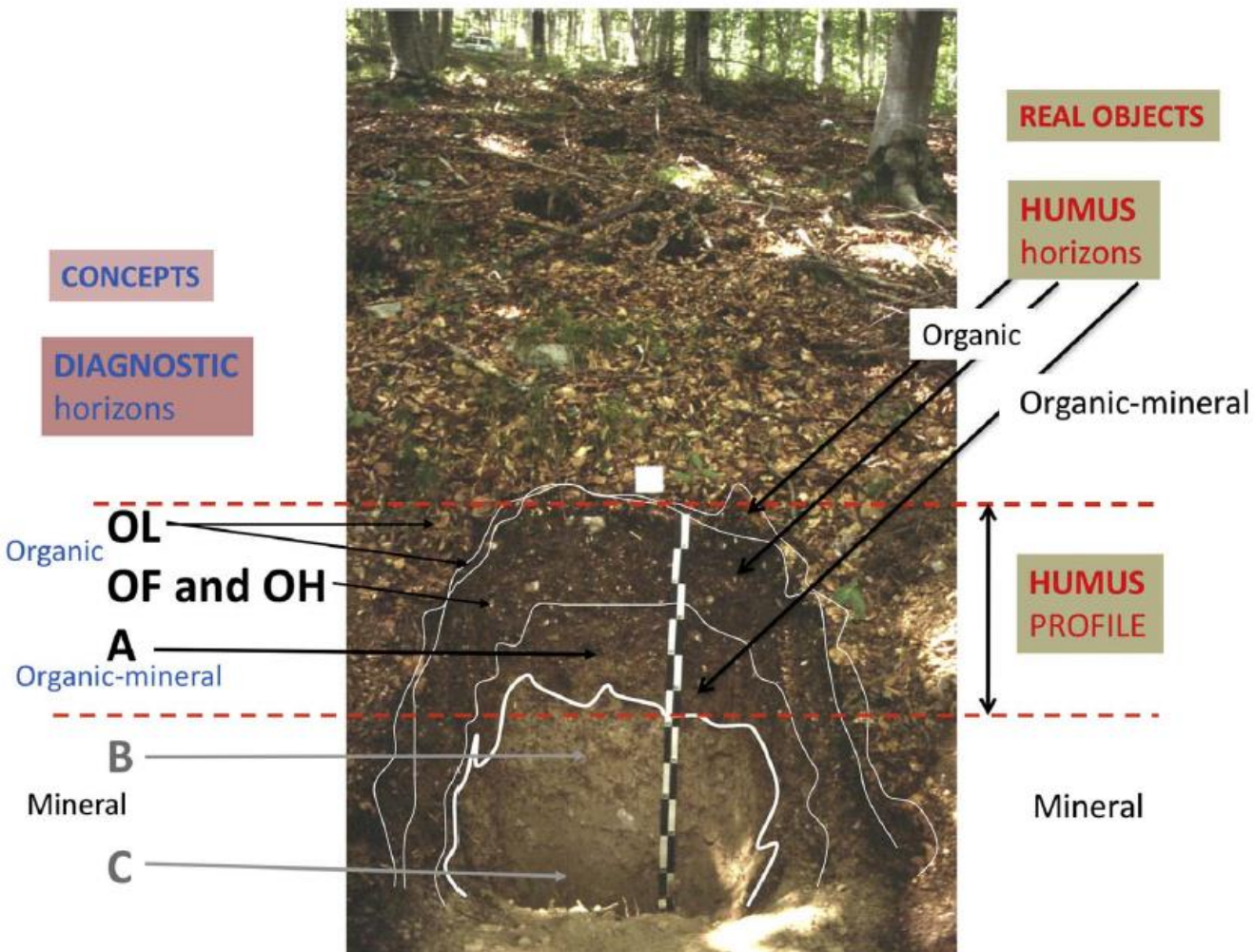


Fig. 5. Example of a hole dug for the observation of the humus profile in a beech forest in Trentino (Italy). Humus system: Amphi; Humus form: Biomesoamphi; Soil: dystric Cambisol (IUSS Working Group WRB, 2015). To the left are concepts used in the classification of humus systems and forms (diagnostic horizons with their letter coding). To the right are real objects as they can be observed by a naive field observer (humus horizons of varying colour and depth, humus profile).

Zanella et al. Applied Soil Ecology 122 (2018) 42–55

Organic matter in soil profile

Vertical distribution



Mullamuseum ©



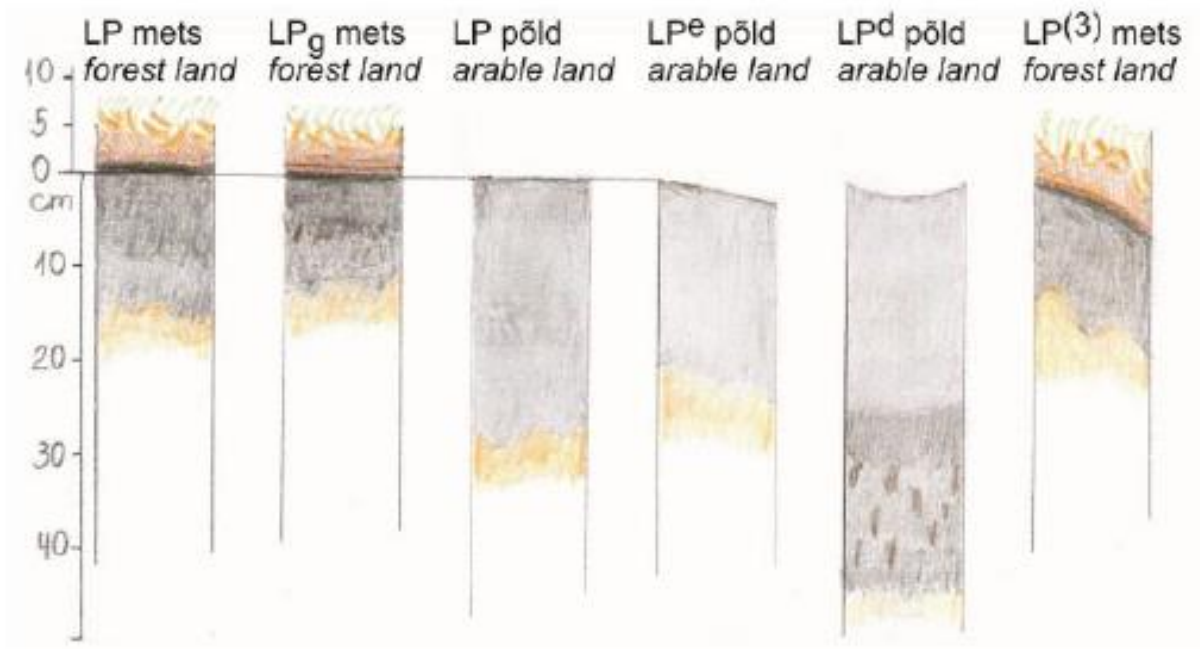








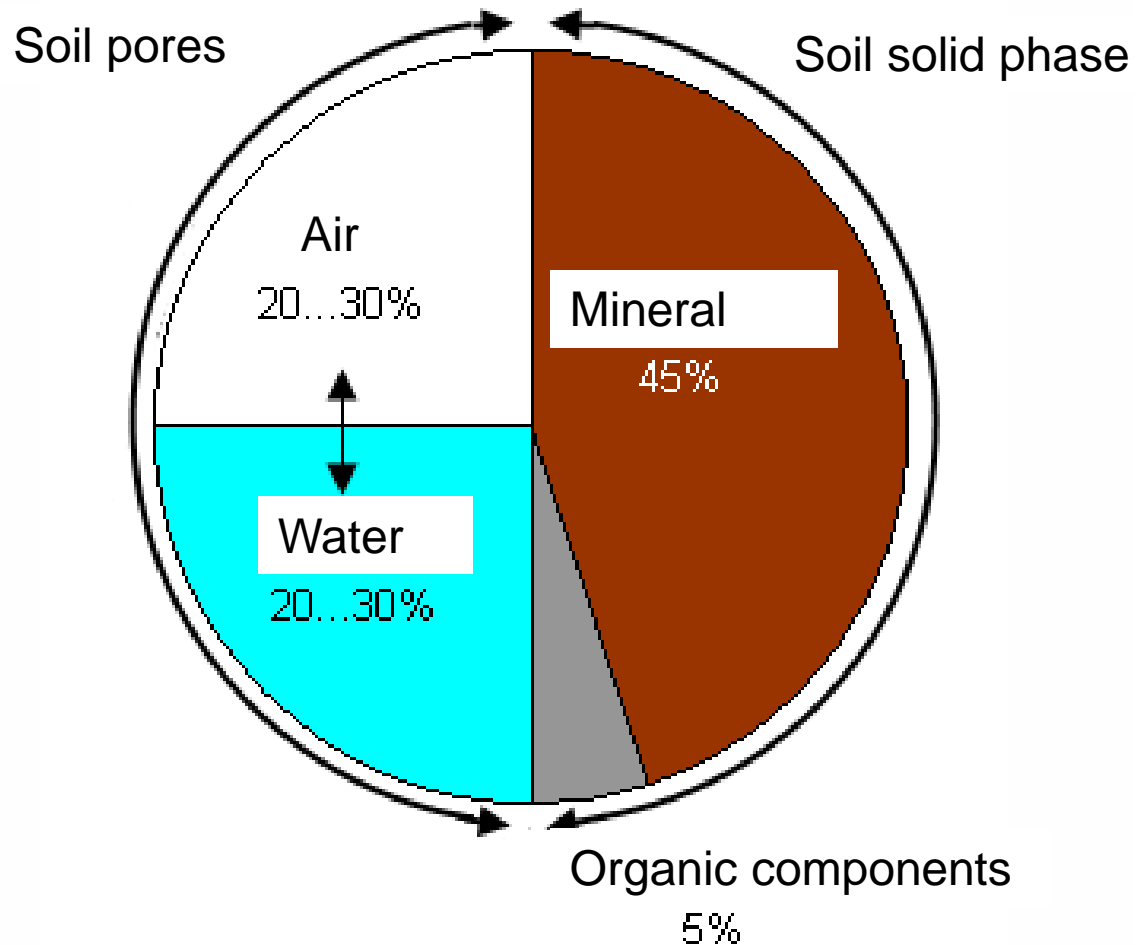
Humus profile is soil type specific but differs depending on land use...



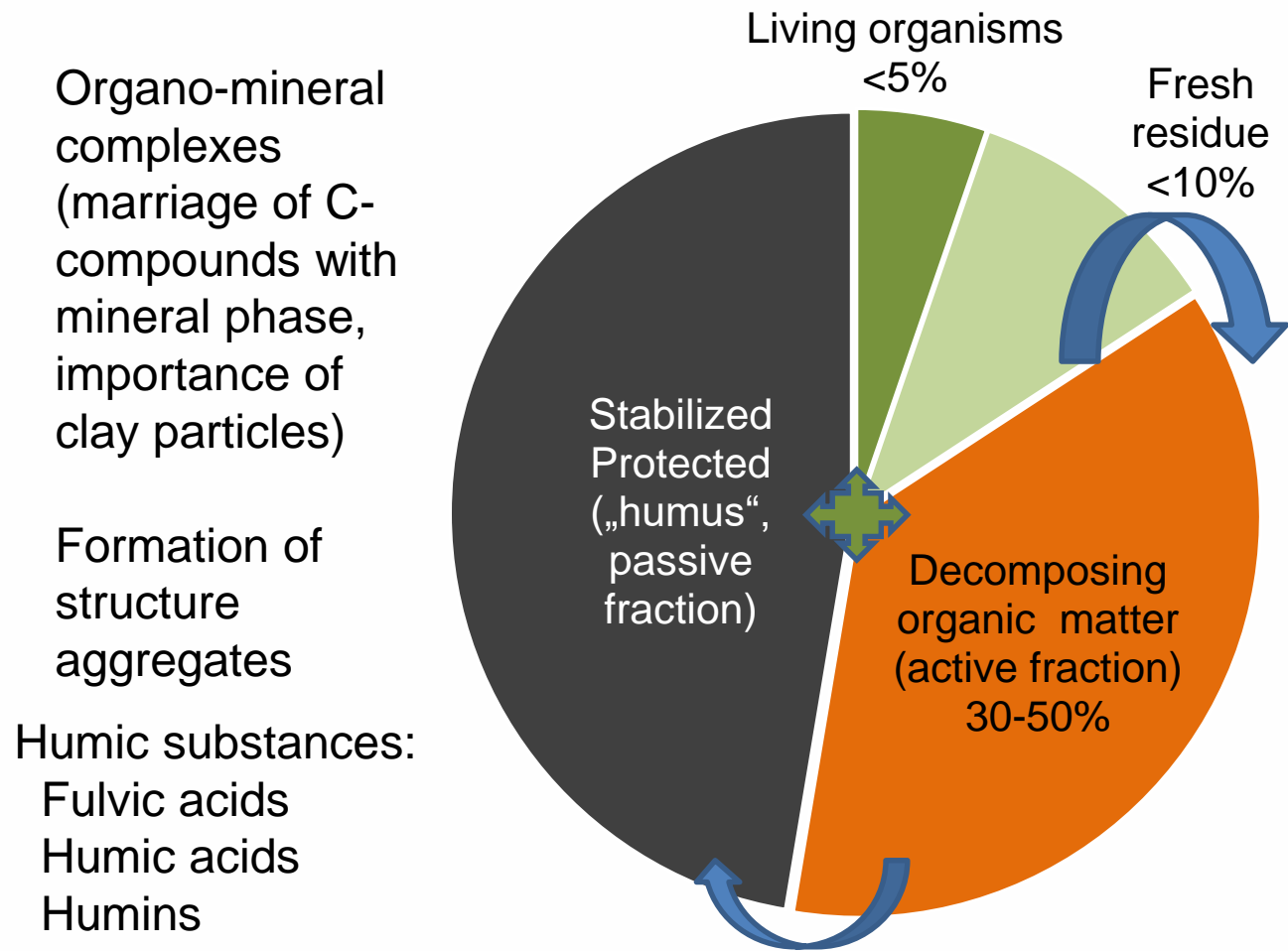
Joonis 8. Kahkjate muldade humuskatete morfoloogia sõltuvalt maakasutusest ja mulla liigist (R. Kõlli)
Figure 8. Morphology of Pseudopodzolic soils' humus cover in dependence of land use and soil species (R. Kõlli)

Kõlli et al. 2018

„Typical“ mineral topsoil by volume



Soil organic components



- *humus* – in latin „earth/ground(soil)“
Basis for words
 - *human* in English
 - *homme* in French
 - *hombre* in Spain

- Should soil scientists stop using terms like "humus", "humic", or "humification"?
(Jan 4, 2016 ResearchGate)
[https://www.researchgate.net/post/Should soil scientists stop using terms like humus humic or humification](https://www.researchgate.net/post/Should_soil_scientists_stop_using_terms_like_humus_humic_or_humification)
- Humus does not exist?

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The contentious nature of soil organic matter

Johannes Lehmann & Markus Kleber

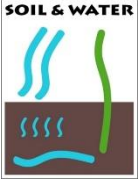
[Affiliations](#) | [Contributions](#) | [Corresponding author](#)

Nature **528**, 60–68 (03 December 2015) | doi:10.1038/nature16069

Received 30 April 2015 | Accepted 08 October 2015 | Published online 23 November 2015

„...available evidence does not support the formation of large-molecular-size and persistent ‘humic substances’ in soils. Instead, soil organic matter is a continuum of progressively decomposing organic compounds“.

They claim that humic substances are result of chemical analysis



Soil organic matter and carbon

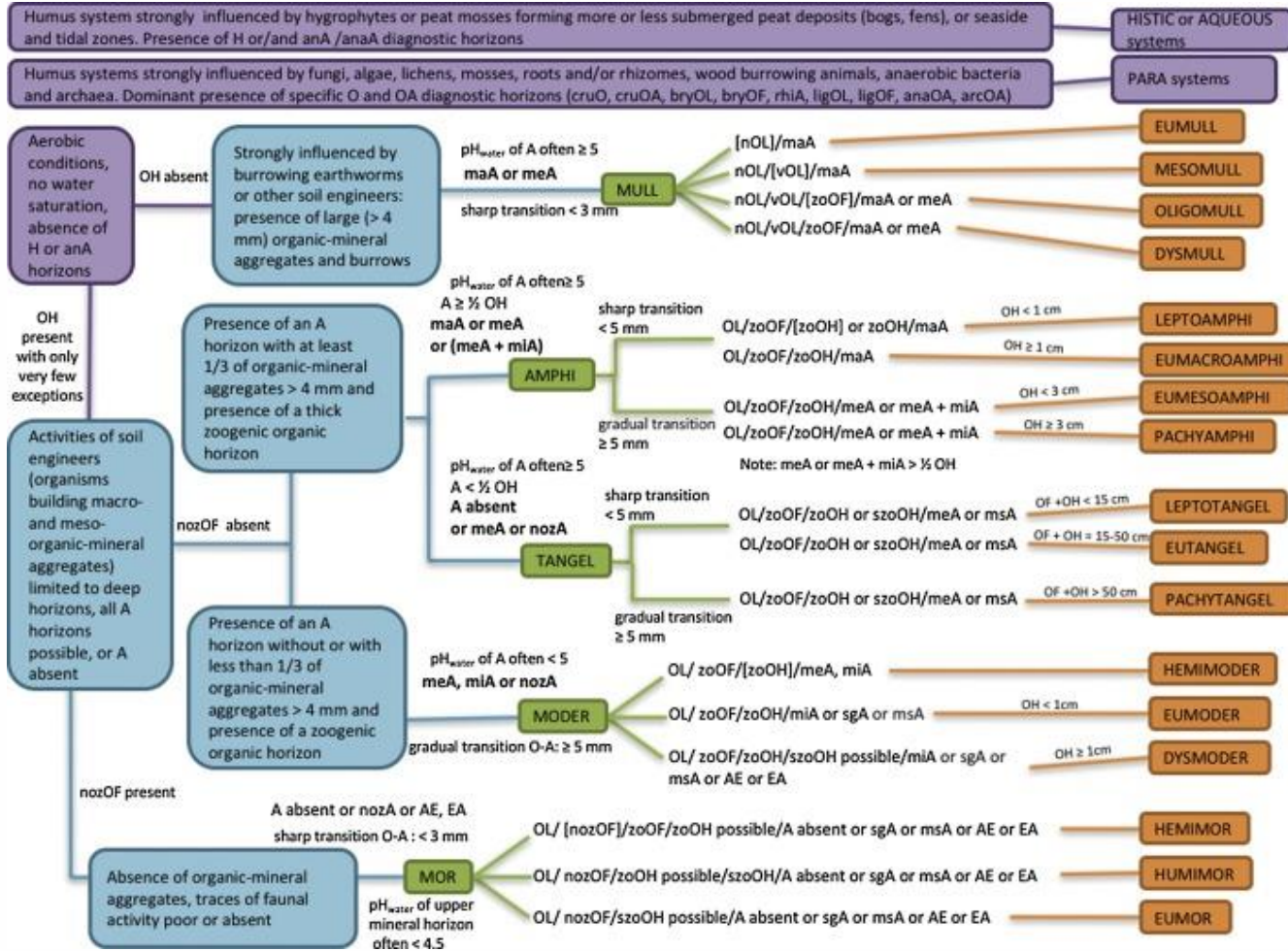
- Quantative methods – lab analysis
- Qulitative methods (concepts) – mainly visual assesment (humus forms)

Humus forms

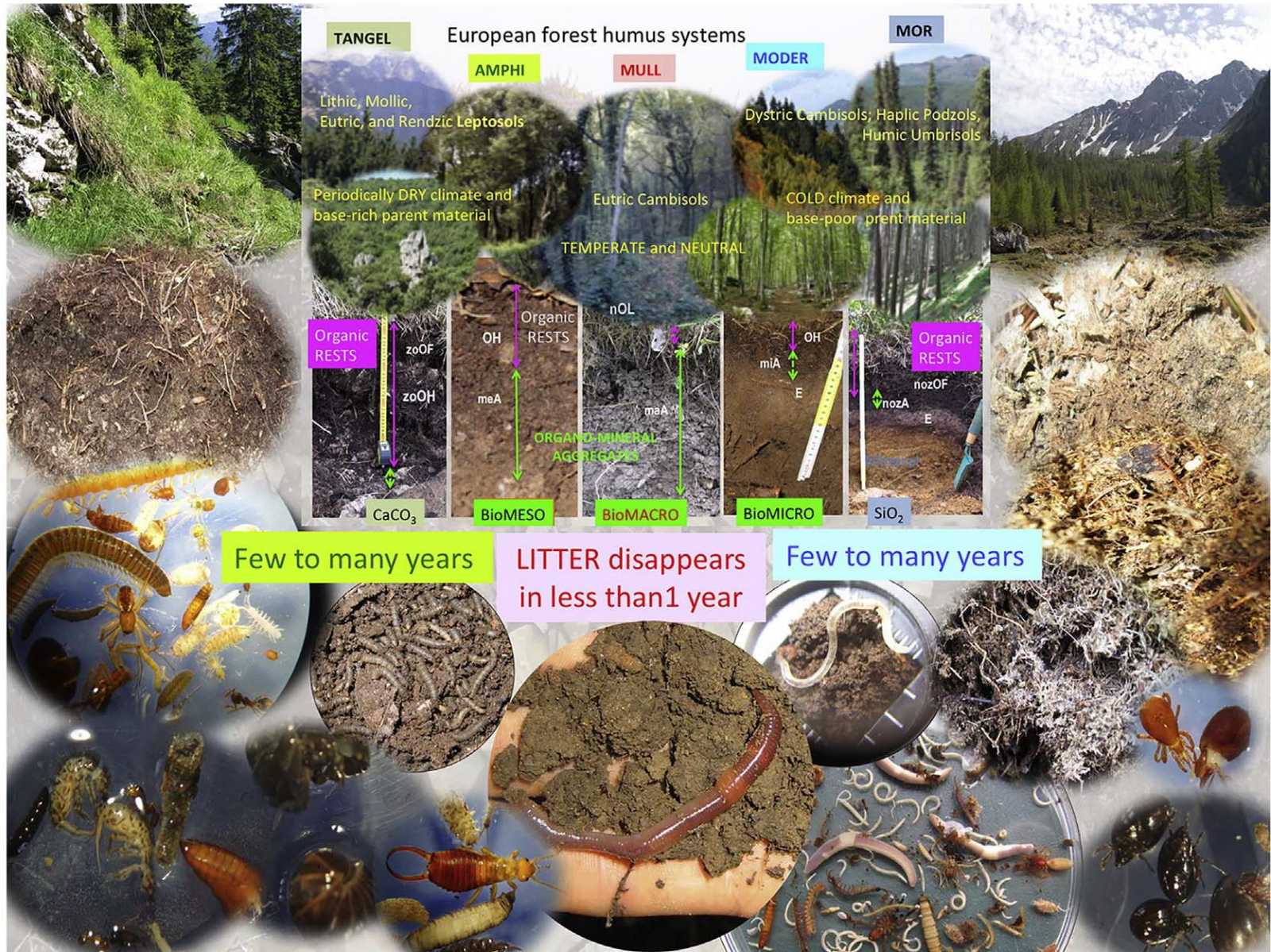
- Humus forms
 - mull – moder – mor (... and more detailed classifiers may be used)

Humus forms

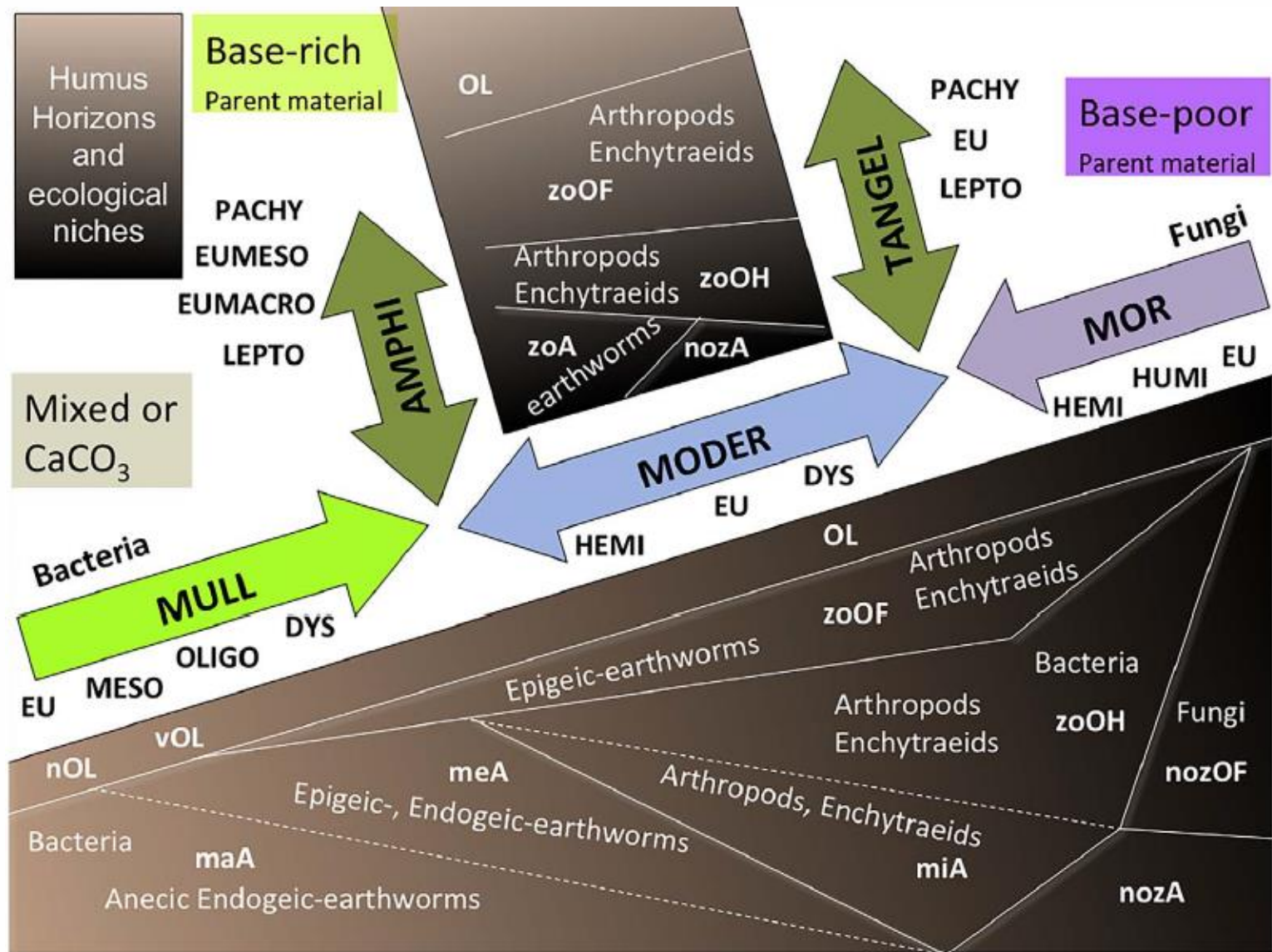
– Series „Humisca“ in journal Applied Soil Ecology



Zanella et al 2018
<https://doi.org/10.1016/j.apsoil.2017.06.012>



Zanella et al. 2018



Zanella et al. 2018

Quantitative methods

- SOM is typically estimated to contain 58% C (soil organic carbon – SOC)
 - van Bemmelen factor 1.724 (from year 1890)
- In reality it varies (1.4...2.5)

Pribyl 2010: A critical review of the conventional SOC to SOM conversion factor. Geoderma. <http://dx.doi.org/10.1016/j.geoderma.2010.02.003>

How its concentration is measured?

- Soil organic matter
 - Loss on ignition (LOI)
 - NIRS (non-destructive method)
- Soil organic carbon (C_{org})
 - Element Analyzer (Dumas dry combustion)
 - Wet chemistry (wet combustion – Walkley-Black, Tjurin) – 5 to 30% lower value compared to dry combustion

NB! Mineral carbon (mineral carbonates - $CaCO_3$ mainly, must be „eliminated“)

Soil organic carbon

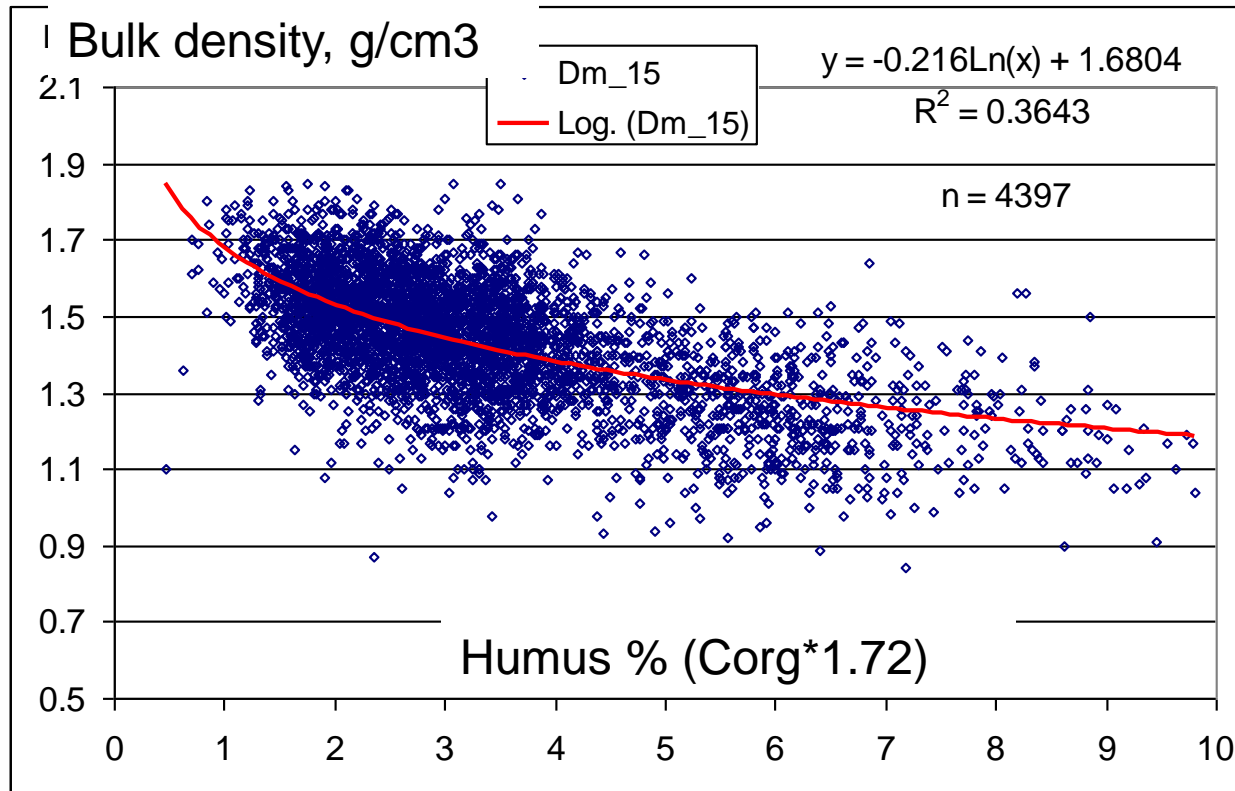
- Concentration (content) - %, g/kg
- Stock (content, density, pool) – t/ha, kg/m²
- SOC stock is always calculated value

SOC stock =

soil volume (depth*area) * coefficient of fine fraction* soil bulk density * SOC%

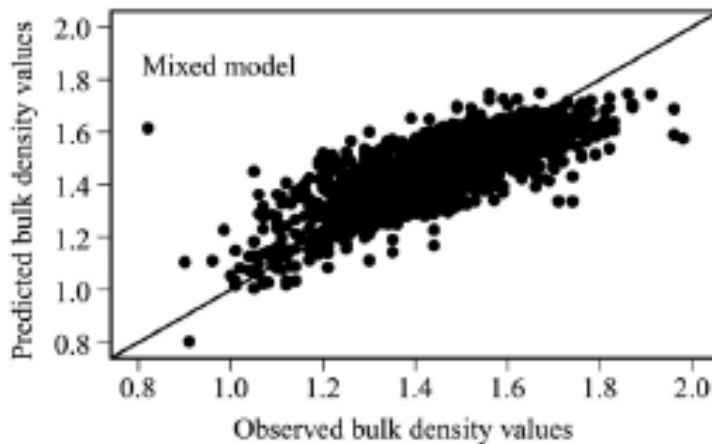
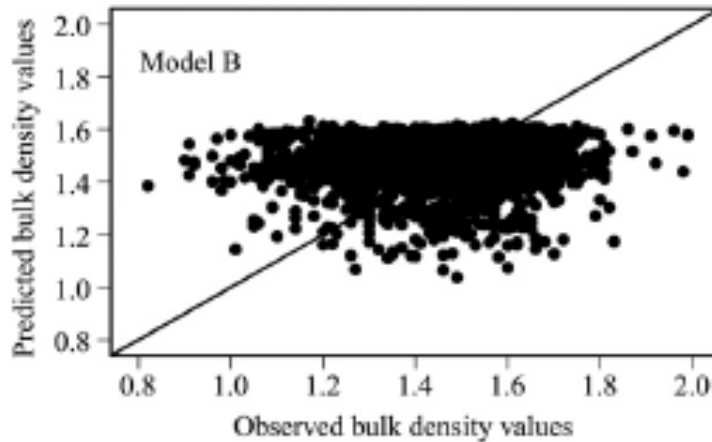
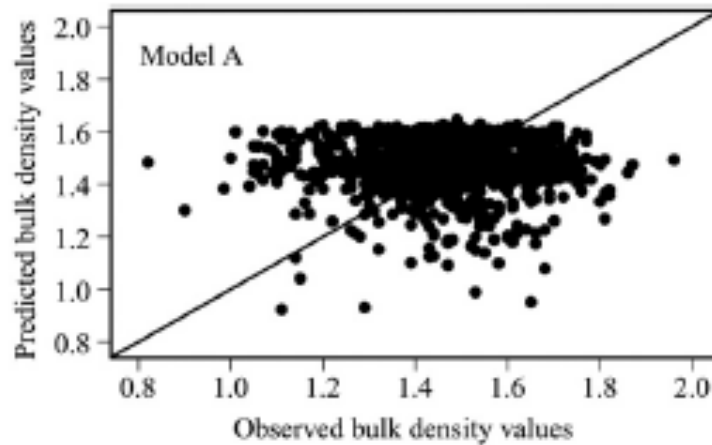
- More carbon in soil – lower bulk density

Dataset from Estonia – monitoring of arable soils (depth 15 cm)



- Bulk density is often not measured, instead of that modelled values are used

Pedotransfer functions



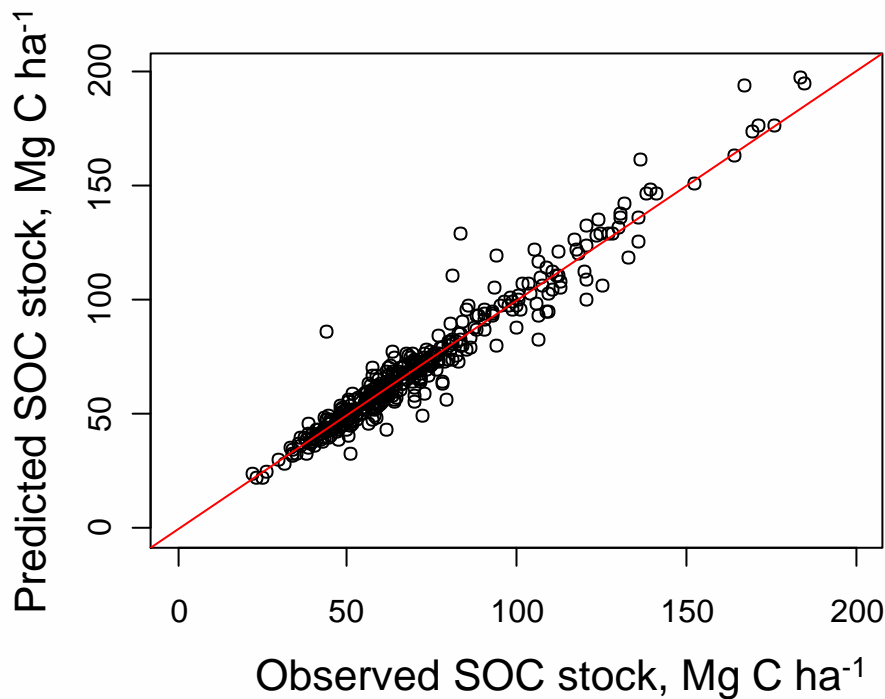
- Current example:
 - Prediction of soil bulk density
 - Humus layer of arable soils

Suuster et al. 2011 - Geoderma



Example of SOC stock modelling

Mixed model – **RMSE 7 Mg C ha⁻¹**



SOC stock, Mg C ha⁻¹

Method	Average	RMSE
Median	66	19
Regression	64	22
Mixed model	71	7

If you look for change in SOM/SOC

- ... it depends on balance of input and decomposition
- ... on initial status
- ...

SYSTEMATIC REVIEW PROTOCOL

Open Access



Which agricultural management interventions are most influential on soil organic carbon (using time series data)?

Neal Robert Haddaway^{1*}, Katarina Hedlund², Louise E. Jackson³, Thomas Kätterer⁴, Emanuele Lugato⁵, Ingrid K. Thomsen⁶, Helene Bracht Jørgensen² and Per-Erik Isberg⁷

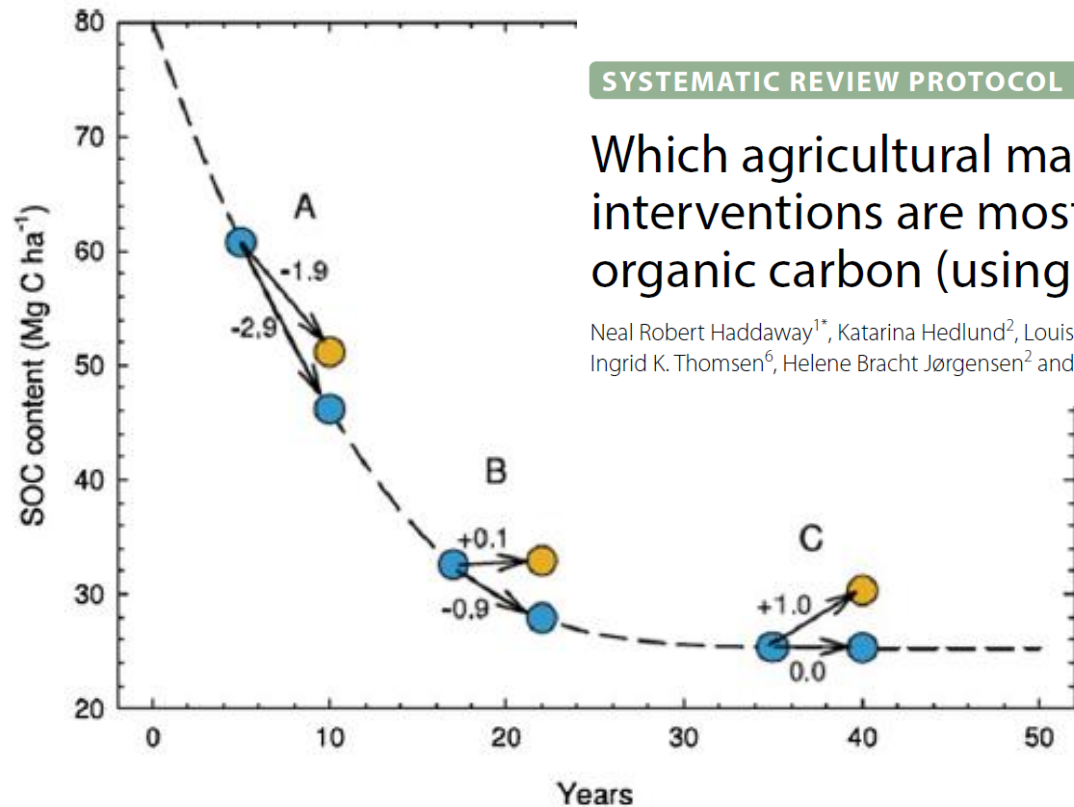
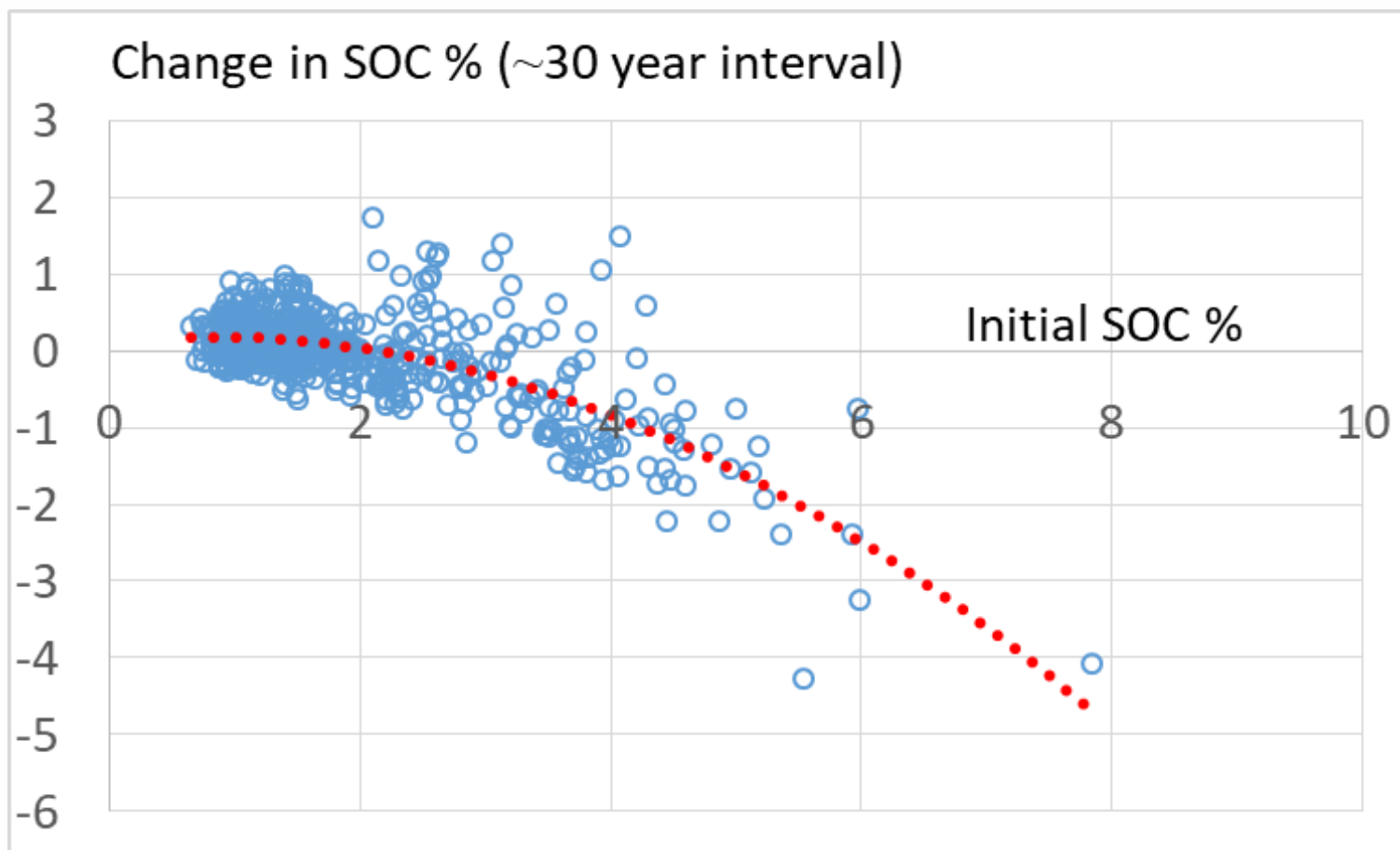
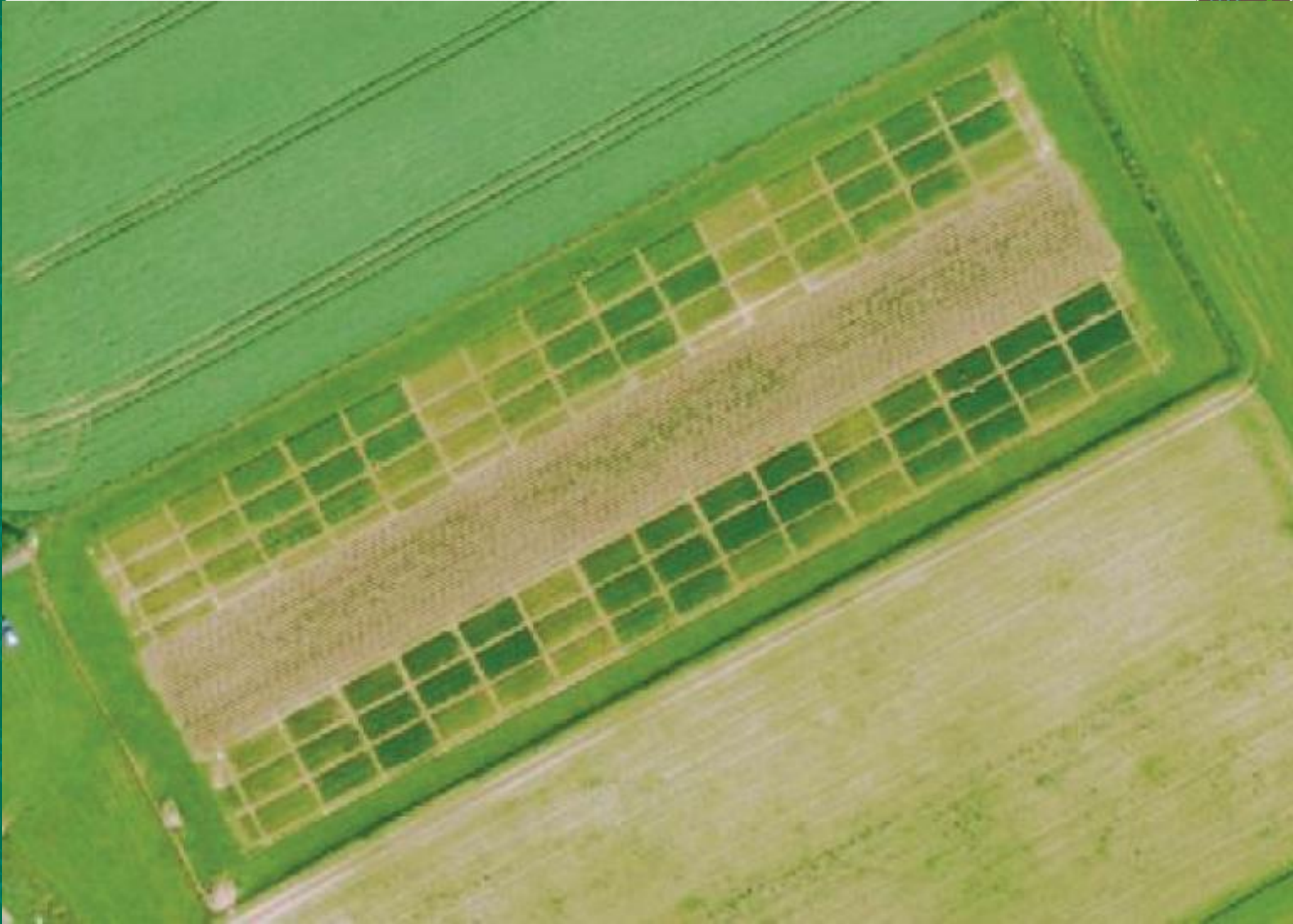


Fig. 1 Soil organic carbon (SOC) content over time for conventional and improved management. The graph shows how a hypothetical management intended to improve SOC may have a relatively higher SOC content at a specific point in time than conventional management, but the absolute level of the stock of SOC is declining at an exponential rate. Reproduced under CC BY license from [13]

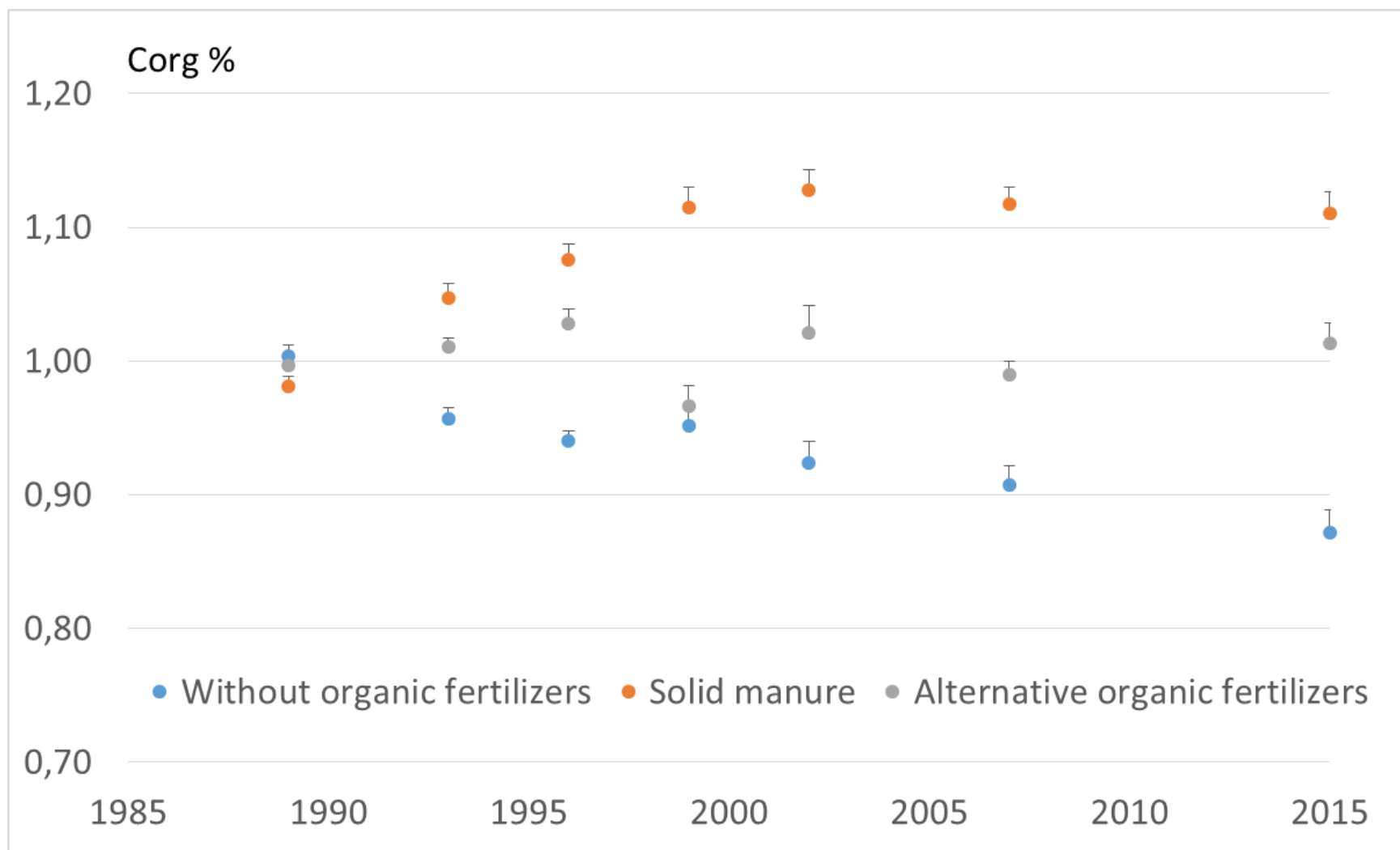
SOC % change depending on initial status (soil monitoring of agricultural soils in Estonia)



Long-term field experiment in Estonia (since 1989)



Change in Corg concentration depending on the use of organic fertilizers





<https://soilsmatter.wordpress.com/2018/08/15/how-can-i-help-my-soil-hold-more-carbon/>

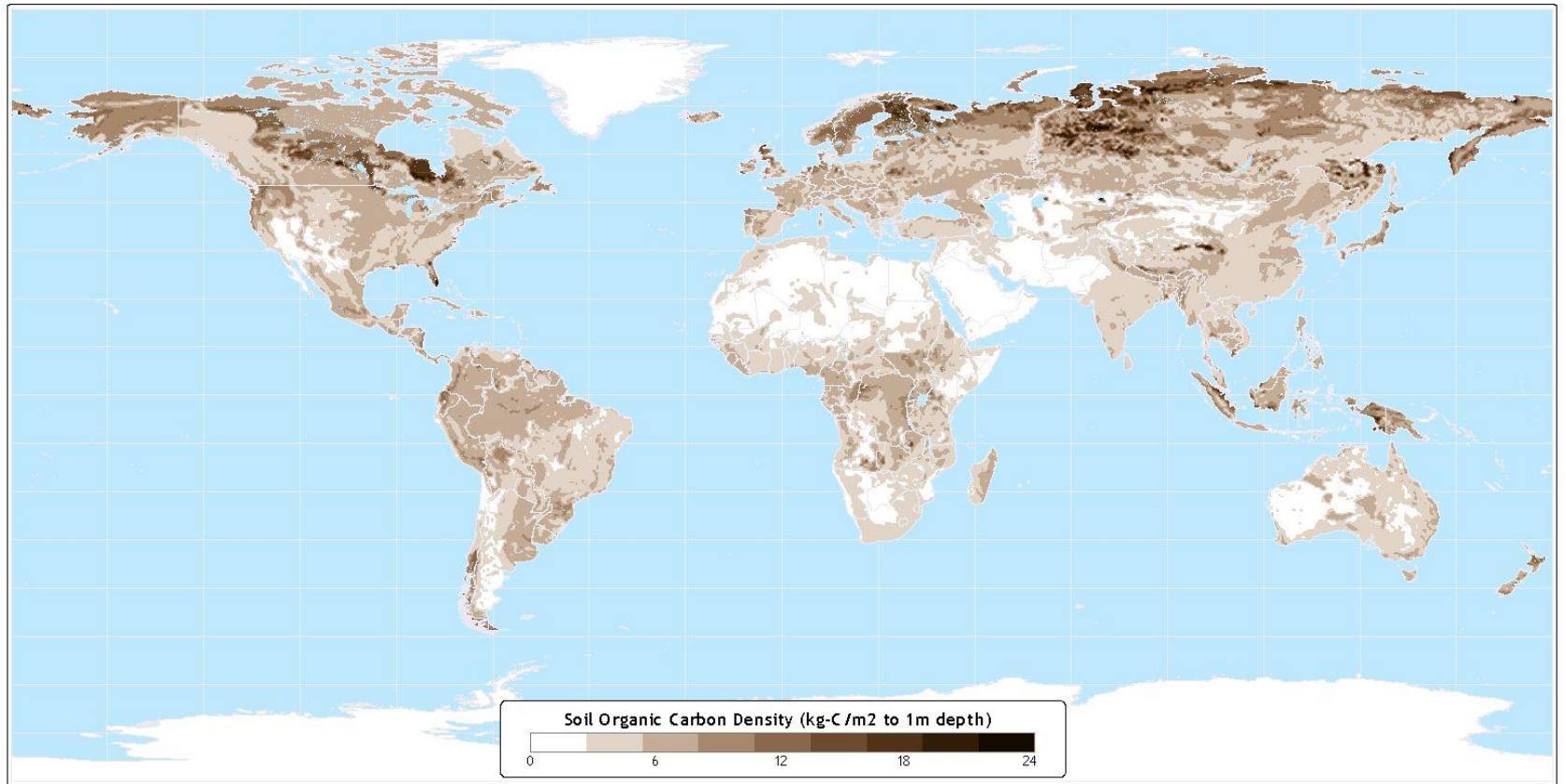


Temporal changes in SOC status at soil monitoring sites

– Estonian agricultural soils

Time period	A horizon (cm)	SOC (%)	SOC stock (t ha ⁻¹)
1983–87 (n=620)	27 ^a	1.86 ^a	58 ^a
2013–16 (n=620)	31 ^b	1.82 ^a	62 ^b

Soil Organic Carbon Density

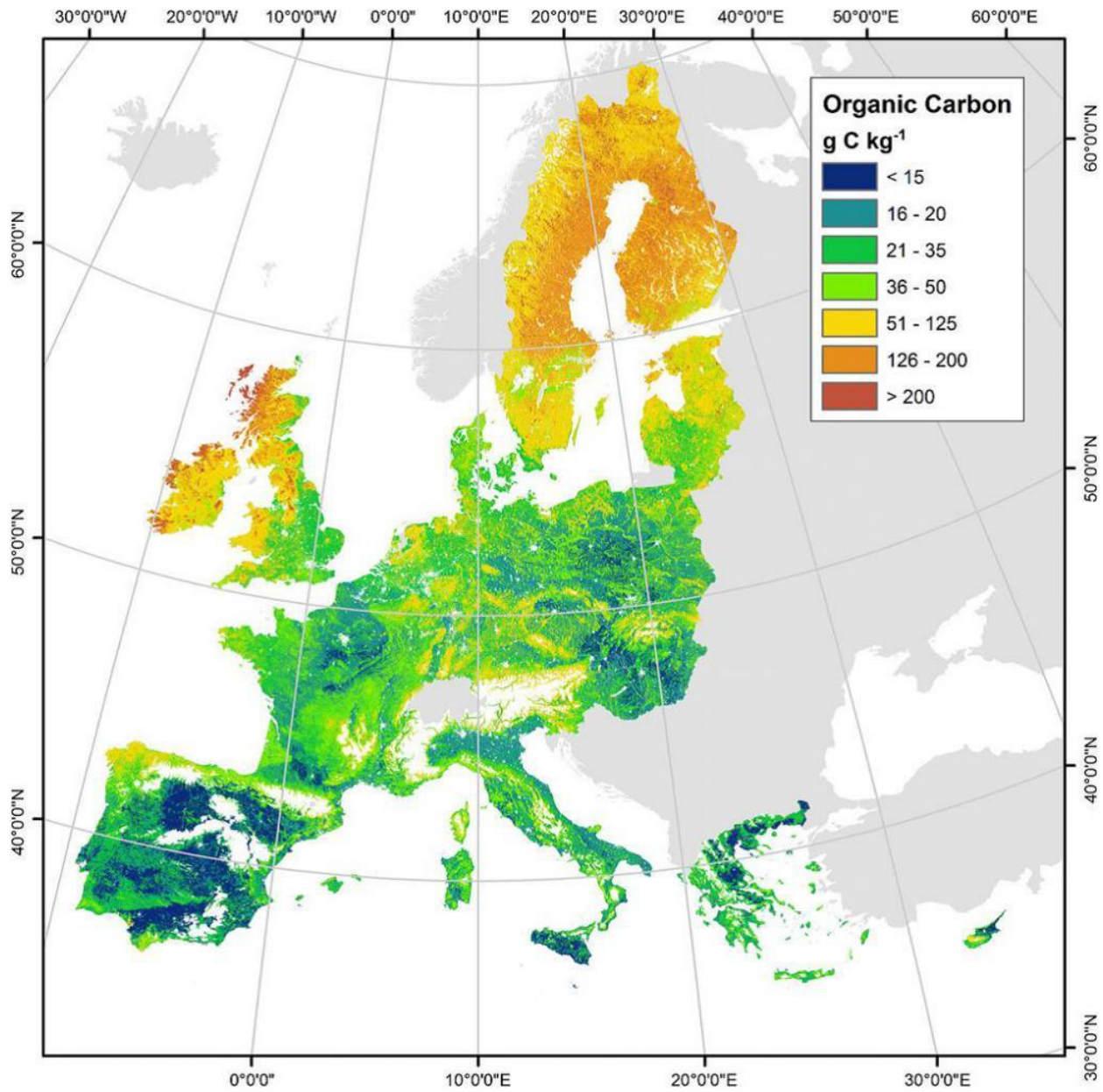
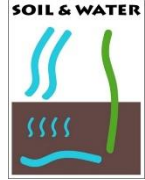


Data taken from: IGBP-DIS Global Soils Dataset (1998)

Atlas of the Biosphere

Center for Sustainability and the Global Environment
University of Wisconsin - Madison

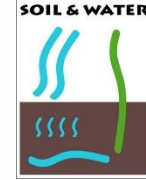
https://nelson.wisc.edu/sage/data-and-models/atlas/maps/soilcarbon/atl_soilcarbon.jpg



<https://ec.europa.eu/jrc/en/news/european-map-topsoil-organic-carbon>

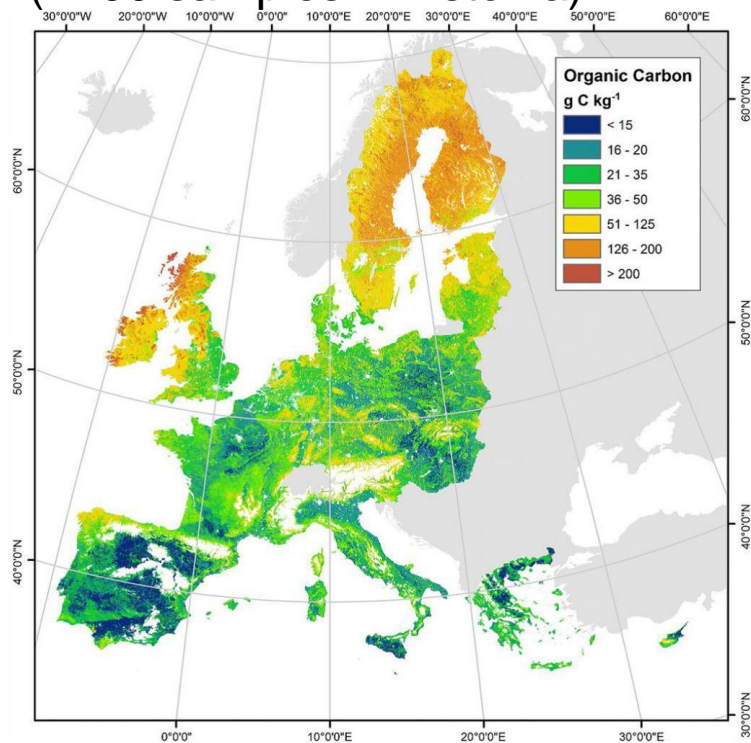


Soil monitoring at various scales – example of soil organic carbon

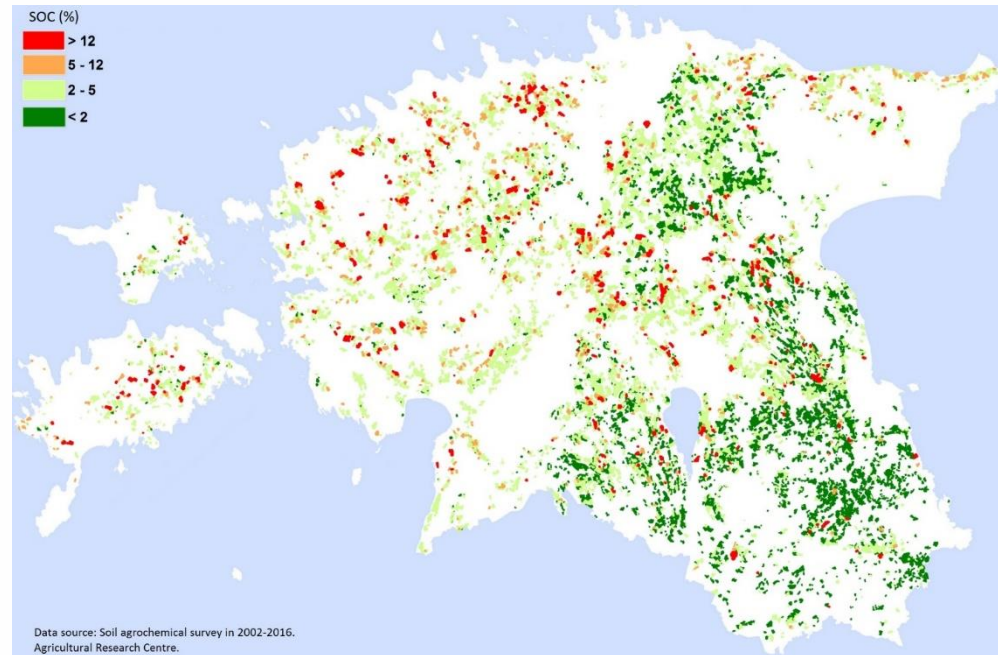


Pan-European LUCAS survey in 2009

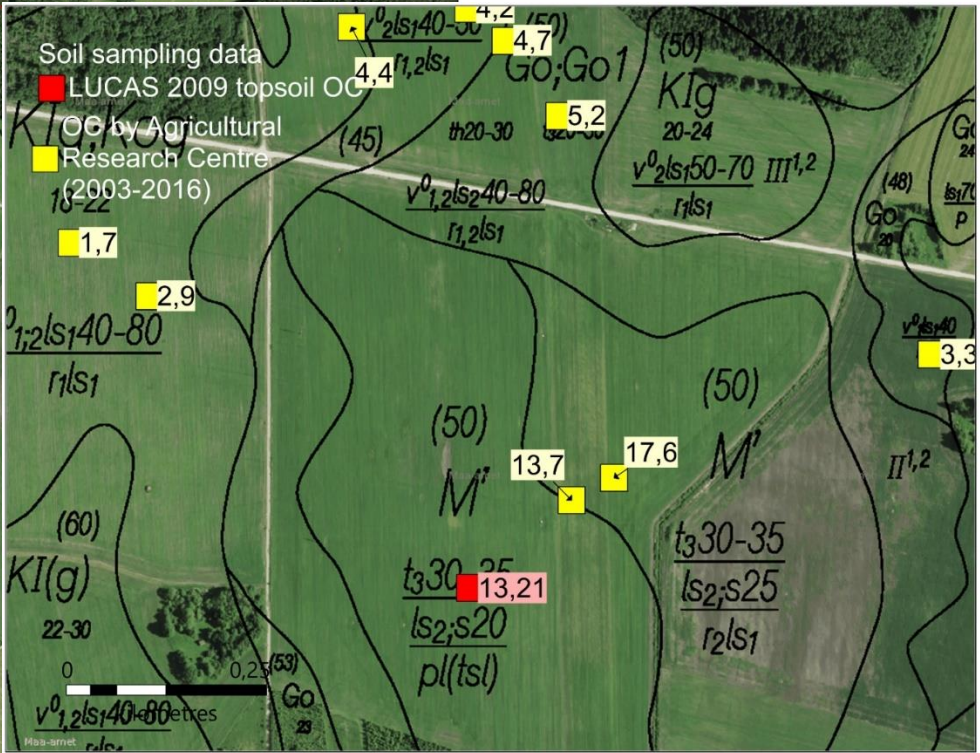
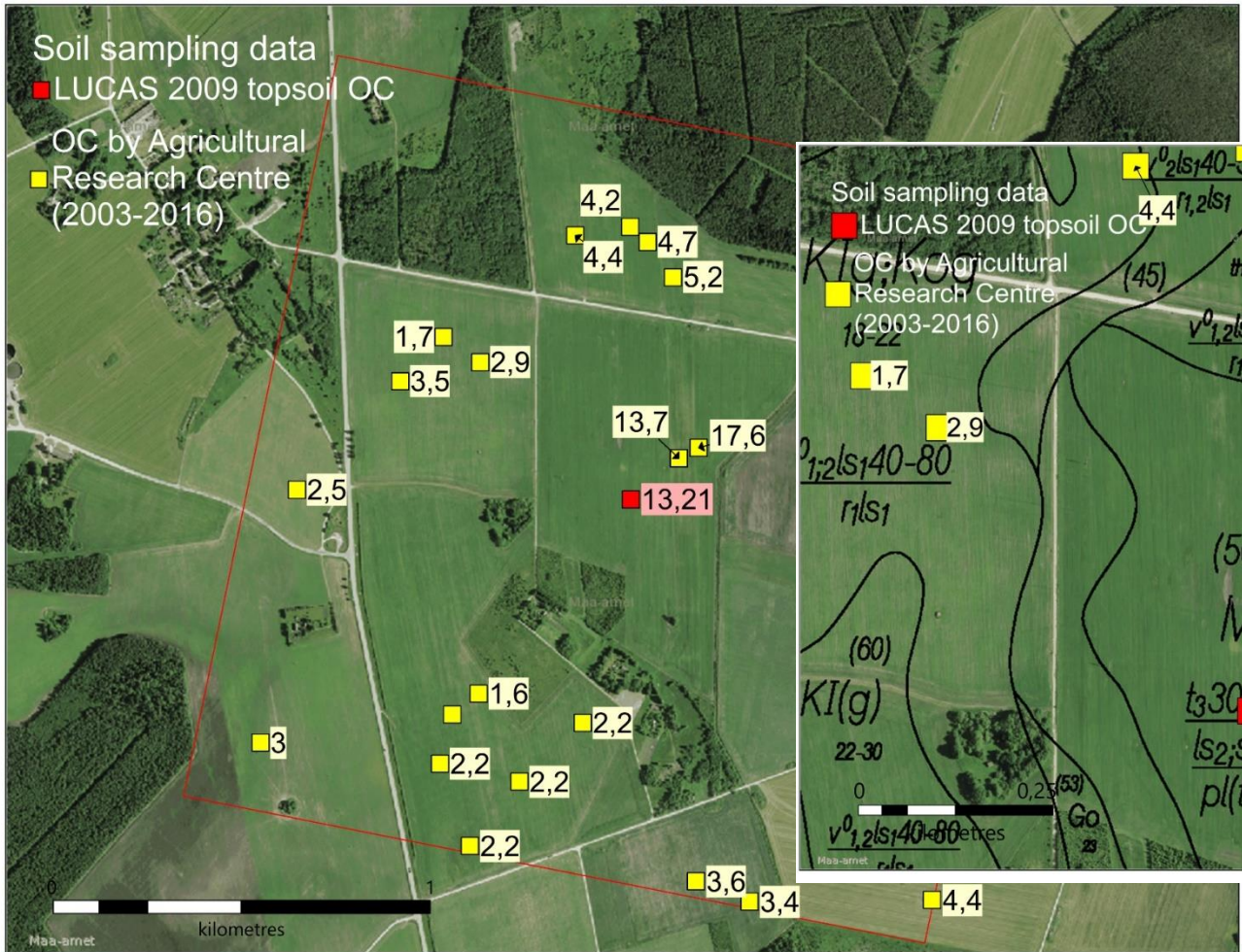
(~200 samples in Estonia)



Estonian agricultural land
(23 885 samples)



<https://ec.europa.eu/jrc/en/news/european-map-topsoil-organic-carbon>



Thank You for attention!

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